Journal of a Fish Production Technician

Prepared for Oceanic Institute

by
Mark Suiso

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ABSTRACT

This journal is a comprehensive description of my experience as a technician with the fish production staff at Oceanic Institute. It describes methodes of collecting fish, primarily different sizes of mullet (Mugil cephalus) and awa or milkfish (Chanos chanos). It then describes how these fish were quarantined, healed of injuries and disinfected before introduced to the resident fish. The fish were fed various diets, according to their suspected needs and what they would eat. Diseases occured but were not often properly diagnosed or cured; however, a few were and some methods for disease identification were described. The work done by me was all in preparation for the artificial inducement of spawning of fish. Mullet was however, the only species successfully induced to spawn. The technique involved hormone injections, then special techniques for incubating eggs and rearing larvae.

1.00 INTRODUCTION

1.10 PURPOSE

This journal describes my duties as a fish production technician. It is intended to serve as a guide when training fish production technicians. It is also intended to help anyone interested in the aspects involved in raising fish on a large scale.

1.20 BACKGROUND

The Oceanic Institute at Makapuu Point is primarily an aquacultural research facility for the development of spawning and rearing techniques of tropical marine food-fish. They have become well known by developing á technique for artificially inducing stripped mullet (Mugil cephalus) to spawn. They are currently working on a similar technique for awa or milkfish (Chanos chanos). Both of these species are important proteins sources in the tropical world. The Oceanic Institute also has an engineering and pathology staff that supports the balance of its aquaculture research.

In June of 1975, I was hired by them as a fish production technician. I worked at that position for three consecutive summers and for the 1975 - 1976 school year in a part-time capacity. I hoped that this would give me the practical experience needed for a career in aquaculture.

1.30 PROBLEM

I found that instructional supervision was minimal because everyone had too much of their own to do or the task was new to the supervisor as well. The procedures developed were the result of many hours of trial and error or of colleagues recommendations. We were often given taskes unfamiliar to us and after some expense worked out a solution;

only to find that someone else already had a reliable method or to find that the other technician did not know you were familiar with the task and would start from scratch unnecessarily.

1.40 SCOPE

This journal contains the methodology I used and my recommendations for the chores assigned to me. These responsibilities are divided into six major areas: fish collecting, handling and quarantine of collected or transported fish, feeding of the fish, disease identification and treatment, inducement of spawning and larval rearing, and animal management toward maintaining a suitable environment.

2.00 FISH COLLECTING

This section describes methods of capturing specimens found most effective and least injurious. The equipment used and the fisherman's responsibility were well worked out. It describes methods of capturing post-larval awa, juvenile mullet and awa, adult striped mullet and awa, and other species. There is also a separate section on seining of fish ponds.

2.10 POST-LARVAL AWA

2.11 General

Post-larval awa or milkfish (Chanos chanos) were found mainly during the late summer and fall (July to September). These fish are approximately 3 to 6 weeks of age and in comparison to mullet of the same age, are quite hardy. The fish are 1.2 to 2 centimeters standard length, very thin and transparent. They were found in estuaries with fresh water sources. The Hawaii Kai drainage on Wainiha Street was found to be most productive; 5000 plus larvae in one season. The fish are usually concentrated at the extreme upper reaches in sometimes fresh water less than one inch deep. When in these confines they are fairly easy to see if you stop and look for the shadows and ripples they cast.

2.12 Materials

The materials used were:

several	fine mesh aquarium nets
2	100 liter tanks - ½ full with water at 20‰ salinity
2-3	20 liter buckets with handles
2+	fisherman
2+	poloroid lenses
2+ pairs	wading shoes
1 cup	vegetable oil

2.13 Procedure

Once the larvae were spotted they were gently but quickly scooped up, for they were fairly rapid swimmers. It is said that if the fish are difficult to see, especially if windy, a teaspoon of vegetable oil put on the surface creates a slick that makes sighting easier[1]. If no fish were sighted we scooped for larvae from areas of shelter (tree branches, rocks, walls) or the upper reaches of the estuary. Larvae are caught, but much less efficiently.

When scooping the larvae care must however be taken not to disturb the soft bottom sediments because it then becomes difficult to see but more importantly the sediments seem to cling to the fish and cause irritation which lead to infection. The scooped fish are then softly put into the bucket with water of the same temperature and salinity. Once there are about 200 fish in a bucket it should be put into a cold transport tank and the oxygen turned on and a small amount of antibiotic added[2]. The best way to put the larvae into the tank is by putting the bucket in the tank and slowly displacing the water.

2.20 JUVENILE MULLET AND AWA

2.21 General

The capture of juvenile mullet was seasonal with striped mullet (Mugil cephalus) most readily caught during the summer months (June to September). The white mullet (Chelon engelai) occur in the same general areas throughout the year, but were relatively more common during winter and spring (February to June) with large juveniles 8 to 10 centimeters frequenting during late summer (July to September). The two species were rarely of the same size at the same time.

Both mullet species were captured in estuaries with fresh water sources, soft bottom (high concentrations of organic matter), shallow (less than 1 meter deep) and sheltered waters (Figure 1 and Table 1). The mullet juveniles captured ranged in length from approximately 2.5 to 15 centimeters total length (TL). Juvenile striped mullet larger than 15 centimeters were rarely caught in our nets (white mullet do not get much larger than 15 centimeters (cm)).

Juvenile awa seemed to be sparse throughout the year and were taken mainly during the winter, since they spawn in the summer. The sizes are approximately the same as mullet and are found in the same general areas.

Low tide seemed helpful in capturing juvenile mullet and awa since it seems to concentrate them into schools.

2.22 Materials

The materials used were:

1	large covered transport tank - 1000 liter capacity - 2/3 full of brackish water
several	20 liter covered containers
1	tank compressed air and fine airstone or a battery aerator
1	hand dip net - 1.5 mm (1/16") mesh
1	small mesh push seine
1	fine mesh aquarium net
1	25 meter by 1.5 meter bag seine of 1 cm stretch mesh
1	pair of polaroid lens per fisherman
1	pair wading shoes per fisherman
2 or 3	fisherman

2.23 Procedure

As mentioned earlier an area of fresh water flow seemed to support the juvenile awa and mullet. Awa were not easily seen in the water but the mullet were usually seen swimming in schools. The bag seine was used most often especially in large areas. The net was walked out

Figure 1 Oahu Fish Map

Table 1
OAHU FISH MAP - JUVENILES - 1976

	Location	Month Fished	Fish Caught
1.	Wailua River	July - August	many species of juvenile fish in large numbers
2.	Haula, Panalu, Kahana streams	July - August	varying amounts of juvenile striped mullet
3.	Waikane stream		said to have awa larvae at mouth during low tide
4.	Kahaluu stream		same as #3
5.	Mokapa (Naupia pond)	August	small amounts of varied sized striped mullet
6.	Hawaii Kai	all year	juvenile mullet of all species
	a. near JAIMS	all year	white mullet and striped, small amount of awa, misc.
	b. Wainiha street	all year	abundant with mosquito fish and talapia, white mullet and striped mullet, juvenile awa, large amounts of awa larvae, misc.
7.	Ainahaina at board of water supply pumping station	all year	plenty of all species of mullet, misc.
8.	Ala wai canal source	August	abundant tilapia jelly fish (Aurelia labiata)
9.	Kapalama drainage Dillingham Avenue	August	some tilapia
10.	Keehi lagoon stream on lagoon drive	August	plenty tilapia striped mullet
11.	Aiea stream mouth	August	large schools of tilapia plenty of striped mullet, misc.
12.	Waimalu stream	August	plenty of all kinds mollies Awa awa (Elops hawaiianus) white and striped mullet
13.	Westlock streams	August	tilapia and some striped mullet
14.	Maili Lualualei river	August - October	various juveniles (mullet, awa, misc.)

to a full extension. The area was surrounded as quickly as possible then slowly pulled in, forcing the fish into the bag. The weights were kept on the inside and the floats on the outside to keep the fish from swimming under the net.

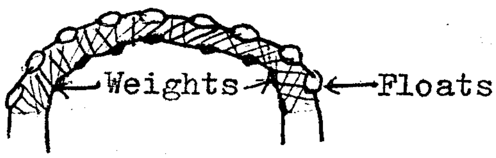

Figure 2 Seine Net Technique

As the net was pulled in the fish began thrashing. When this occured we worked quickly to concentrate them. The fish were scooped out of the bag, placed into buckets and covered. This was done as fast as possible to reduce the stress. If the catch was small the fish were sorted before putting into the bucket. Once the buckets were full (100 plus juveniles) they were emptied in the transport tank and the oxygen was turned on. This also had to be done quickly for the fish are under great amounts of stress while in the net and bucket.

The dip nets and the push seine were used when wading through the estuaries seeking small groups of juvenile or smaller fish.

2.30 ADULT STRIPED MULLET AND AWA

2.31 General

The capture of adult striped mullet (Mugil cephalus) (Figure 3) was made throughout the year, but was highlighted in the fall just prior to their breeding season.

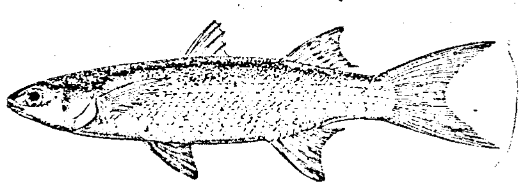

Figure 3 Mullet

Most of the fishing was done in Pearl Harbor's middle loch. Ten to fifteen live mullet could be expected in a day of fishing and they ranged in length from 28 to 40 cm (TL).

Fishing for adult awa (Chanos chanos (Figure 4)) was also primarily in Pearl Harbor's middle loch and just before their spawning season which is in the summer.

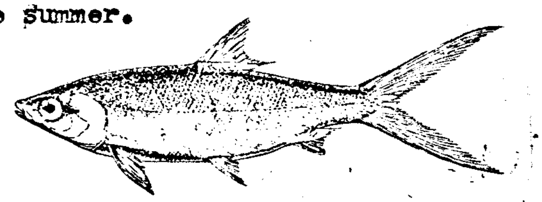

Figure 4 Awa

Sexually mature awa are at least 3 years old and weigh 5 to 20 kilograms. They are 70 to 100 cm in total length. We caught one adult for every 2 to 3 days of fishing.

2.32 Materials

The materials used were:

1	Boston whaler
1	200 meter by 6 meter monofiloment net (6 kg strength with 7.5 cm stretched mesh)
2	5 kg weights (one for each end of the net)
2	large floats
1	large heavy duty dip net - steel rod frame
2	oxygen bottles (2000 + psi)
1	small battery powered water pump
1	flow through transport tank with cover
1	scapel with spare blades
1	1000 liter transport tank with cover - 2/3 full of brackish water
20 kg	crushed ice
3	fisherman

2.33 Procedure

When fishing in Pearl Harbor, we fished without seeing any fish because of the depth and turbidity of the water. The nets were lowered at previously successful areas such as sewage outfalls, channels or ledge drop-offs, from mud banks on an incoming tide. The net was layed in the bow on a platform. The weights were placed on one side while the floats were placed at the other side of the bow, with the middle of the net bunched in the center.

When setting the net the driver puts the boat in reverse and formed an elongated C - shape, while another fisherman helped the net out if needed. Once the net was set we chased the fish into the net by pounding the sides and rocking the boat in a zig-zag pattern toward the net. This took a few minutes and then the net was promptly pulled in.

The procedure used here was driving up to one end. The motor was then put into neutral or a slow reverse depending on drifting speed. One person would pull the weights up on the inside of the enclosure to one end of the bow, another would pull the floats in at the other side of the bow leaving one to take care of the middle of the net.(see Figure 5).

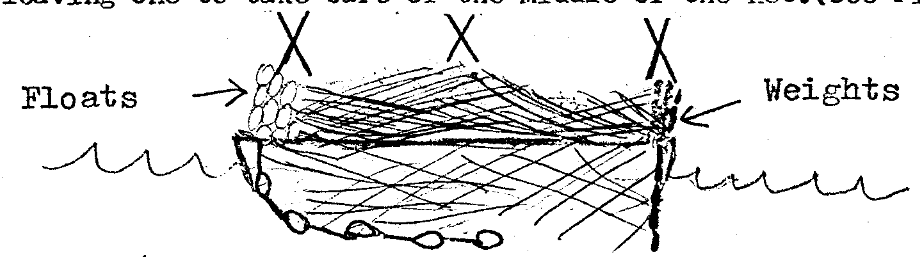

Figure 5 Gill Net Technique

Pulling in the net was done rapidly, quietly and methodically, otherwise the fish would panic and either escape or be further injured. If a mullet was retrieved it was usually gilled and the net was cut with the scapel to avoid excessive damage to the fish. Large awa on the other hand were usually swimming free or lightly hung up. The awa was lifted out with the dip net quietly so as not to panic the confused fish for it could easily break through the netting.

Once these fish are removed from the net they were put into the flow through tank and the oxygen turned on, if the boat was not moving and water not flowing.

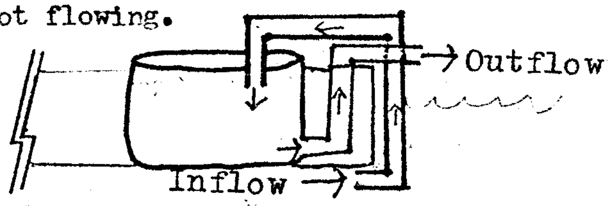

Figure 6 Flow Through Tank

The battery powered water pump was used at times to flush the water when the boat is stationary (mullet and awa shed lots of mucus which fouls the water). The tank was checked periodically with the dead fish removed and to see if the tank is over crowded. A full tank was transferred to the transport tank in the truck as soon as possible or the severe crowding would cause more mortalities.

Before putting the fish in the truck tank, the crushed ice was added to cool the hot tank that was in the sun most of the day. This was found to help calm down the fish. The fish were scooped from the boat tank, hustled to the truck tank, and the oxygen turned on. The cover was then quickly secured to prevent jumping. Darkness was found to reduce much of the fish activity as well.

2.40 SEINING IN PONDS

2.41 General

Many Hawaiian fish ponds were stocked with mullet and awa. These fish were found to serve as an excellent brood stock, but they had to be removed only when fully mature or they did not continue to develop during that breeding season[3]. In addition, collection of these fish usually meant seining the entire pond.

2.42 Materials

The materials used were:

3 people

1	large heavy-duty seine (long enough and deep enough for the pond)
2	large, heavy-duty dip nets
2	50 liter buckets with covers
1	oxygen bottle with airstone or a battery areator
1	large transport tank - 1000 liters

2.43 Procedure

A landing site was selected where the truck with a transport tank could be closest to the pond. Next, a starting point was selected. Generally this involved the selection of the shortest, least difficult route to drag the nets. We sometimes decided to section off a pond or to scare fish out of one area and quickly pull the net by rope across. Once the seine was stretched across the pond the slow methodical dragging began. The heavier the weight the less careful one had to be when dragging the seine. A third person would swim along the seine keeping fish away and unsnagging when necessary.

At the landing site the ends were pulled in with the weights on the inside; this forms a pocket that helps contain the fish. If the fish started jumping the third person would lift the net top, leaving the weights on the bottom, to stop fish from jumping over.

Once the fish were concentrated enough to ease collecting the fisherman would stop pulling in the net and immediately remove the fish. The more stressed fish were removed first. They were held temporarily in the 50 liter buckets and transferred to the large tank as soon as practical.

2.44 Mature Awas

Mature awa were found to swim up to the gate of the ponds when in season[4]. They entered when the tide was at its highest peak of that month. These fish were easily caught for we just waited for them to swim up; then we dropped the door behind them and with a heavy-duty dip net gently lifted them out.

2.50 COLLECTING DISCUSSION AND RECOMMENDATIONS

2.51 Seine Nets

The seine netting used was found to be the best if made of a soft, heavy-duty, braided nylon with no knots, unless it was used as a gill net. The heavy-duty aspect helps prolong net life especially if used on rocks or with large fish. The soft, braided knotless nylon was found to do the least amount of damage to the fish. This netting if used as a seine should be heavily weighted preferably with heavy lead core lines which allow uniform weight throughout. The heavier the weights the less the chance of fish escaping by sliding under the net. The sewing of this weighted line to the netting was found to be best if sewed close together which reduced the possibility of gaps in the net. In addition gaps also cause the net to tangle easily. If used as a bag net it was found that the bigger and deeper the bag the better, but a bag tends to get holes in it quickly.

2.52 Dip Nets

The heavy duty netting can be used as material for heavy duty dip nets. The frames for these nets had to be strong and steel rods worked best. This dip net can be used for any fish but is essential for adult awa. It was best to have an open bottom with a draw string for easy release. The net must also be deep enough so that the fishes tails do not hit the rim of the net. Awa are such big and strong fish that they can easily hurt themselves by thrashing around.

2.53 Gill Nets

The large monofilament gill net made of lead core line and a thick floating line worked best on the boat. This net had no floats or leads to tangle when being set. The lead core line and floating line also helped by being not to bouyant so it gives when a fish hits, helping to bag the fish and absorb the shock.

2.54 Transport Tanks

The transport tanks had to be covered especially when carrying mullet or they would jump out of the tank. It was also found that if crabs, rocks or sand, other mechanical or biological menances were put into the tank, mortalities would increase during transport. In fact any unnecessary handling of the fish greatly reduced fish performance. Lastly, it was found smaller bubbles from the airstone the greater the absorption into the water. The best airstore I saw was designed by Wayne Baldwin of the Hawaii Institute of Marine Biology (HIMB). This airstore is in actuality a *fine grid grinding stone* with a hollow bolt that forces air through it. The bubbles leave the stone looking like smoke, not only does the fine bubbles cause greater absorption of the water by increased surface area but it also conserves the oxygen consumption by reducing the flow from the tank.

2.55 Transport of Fish by Hand

Everytime a fish was moved or handled by hand it was put under stress and often injured. This often led to complications. If the fish were maneuvered into a plastic bag while still in the water, then lifted out and carried, then injuries were minimal. Large awa were in better condition when transported this way if a strong enough bag was found.[5] It restricted their movement but did not injure their delicate skin.

3.00 HANDLING AND QUARANTINE OF COLLECTED OR TRANSPORTED FISH

After the fish have been captured or handled they were usually injured and by the fourth day display the full realm of their injuries. These injuries are the result of physical abuse together with the trauma of capture and a new environment. These fish were given special treatment and were kept separate because of the possibility of introducing pathogens and pests, as well as giving them a chance to heal.

3.10 PROCEDURE

The procedure we used involved putting the captured fish in a rapidly flushing tank of a salinity between 20 and 25 parts per thousand, irregardless of salinity captured unless the fish is absolutely intolerable to this salinity. This salinity is close to that of body fluids and should be less strain on the wounds suffered by reducing fluid loss. Circular tanks were preferred for constant swimmers since it tends to allow uninterrupted swimming. These tanks must be covered to prevent fish from jumping out, particularly mullet. The first four days a bath of a nitrofurozone (Furacin^{R}) at 9 ppm 2 to 3 times daily. This aids in preventing opportunistic pathogens from invading wounded fish. During these first four days any injuries suffered during capture and handling will become evident. The transparent adipose tissue or skin will begin to cloud and scales will fall from bruised areas.

It was made clear that these conditioning fish were not to be fed unless they appear to be starving to death. If this happens live food is preferred and any uneaten food should be removed. This helps reduce the number of bacteria that will be in the water.

Fish with more severe injuries or wounds that did not heal in a week were isolated and treated separately. These isolation tanks were kept very clean, well aerated and had a high flow of water. Drug treatment varied according to symptoms (see disease section); however, any drug treatment used could have been harmful as well.

3.20 LIFTING THE QUARANTINE

Once healed they were conditioned to feed slowly by giving small amounts several times a day. Any uneaten food was removed after 30 minutes. They were fully conditioned when they ate regularly and at least maintained their weight. The last step before introducing to other fish was a bath for 1 hour in a formalin: malachite green mixture to kill parasites that they may carry. This is not a guarantee to remove all parasites, but it does significantly reduce the possibility of transferring parasites. All of the equipment that was handling the quarantined fish should be disinfected with potassium permaganate and throughly flushed before using again.

3.30 CONDITIONING TO HANDLING

I attempted to condition fish to handling by feeding once daily routine. While feeding, I tried walking in the water slowly and waving my hands in the water slowly touching the fish. There were not significant changes observed, but if the fish were conditioned to handling spawning would be much more effective.

4.00 FEEDING OF THE FISH

Feeding the fish was the second most important responsibility I was given next to fishing. This involved about an hour every day. The fish were fed what they would roughly consume in 10 minutes from one to three times daily (7 to 15% of their body weight per day). Observations were made as to the general health of the fish. Diets ranged from commercial fish feeds (Ralston-Purina catfish chow) to experimental dry feeds (Awa mix see appendix) to frozen fish to live mosquito fish (Ganbusia sp.). For the most part a diet was selected on the basis of their natural diets, considering also their digestive anatomy and feeding behavior. For example, the striped mullet has a small, sucking mouth placed subterminally. A gizzard is present and the intestine is long and extensive indicating a omnivourus or herbavious diet. The gut-contents of wild mullets usually consists of detritas, diatoms, small crustaceans (benthic copepods and small amphipods) and several types of blue green algaes. On this evidence a diet of grains mixed with animal by-products, ground to a mash may be acceptable. Table 2 lists the fish with feeds ranked according to attractability, digestability, frequency of animal disorders and cost.

Variations of a diet and amount to be fed depended on age, reproductive stage and intended use of the animal. The feeds were either in a frozen or dried form; fish, shrimp, krill and squid was frozen and dried feeds consisted primarily of prepared commercial feeds, grains and animal meals. Predatory species were less apt to be conditioned on an artificial diet and were usually fed animal flesh or live food.

Fish kept indoors needed more complete diets than those kept outside. Outside tanks developed a diatom mat on the sides, this was excellent for herbivors and omnivours. This mat also served as a substrate for small crustaceans that entered from the water system and were used as food for small carnivors. These fish were fed supplements to keep them from grazing too much. In general fish did better outdoors especially omnivours and herbivours. Omnivours and herbivours kept indoors were usually given a wide range of foods in a hope that a variety would provide them with more of their requirements than a single food source but they still did not appear as healthy.

4.10 FEEDS USED

Fish were fed what we thought would be best for them. This was, as mentioned in the general section, based on the digestive anatomy of the fish, gut content of wild fish, food available in their natural habitat and their observed feeding behavior. Table 2 is a list of the feeds we found best suited for the species we worked with.

4.20 DISCUSSION

Dry feeds were given attractants such as fish meal in addition to binders to increase palatability, but this was met with only limited success. The fish meal seemed to be a good appetizer but the ground feeds lacked the texture desired by the fish. Therefore I experimented a little with several binders (propylene glycol, gelatin and high gluten wheat). I was strongly urged to use wheat by my supervisor, however I found that wheat was poorly digested and would form a gum with water. Gelatin on the other hand, would bind well if dissolved in hot water, and in concentrations of about 1 to 5 %. However, I was not able to continue to work with gelatin because of a lack of time and lack of support. Pelleting was also attempted, but proved to be too slow to be practical.

Table 2 Feeds Used

Animals	Food/Remarks*
1. Crustaceans	pieces of fish flesh, squid, frozen krill
2. Carangids (jacks)	live mosquito fish, smelt, chopped fish, squid, rarely trout chow
juveniles	live small mosquito fish, krill, isopods, amphopods, brine shrimp
3. Mullids (goatfish)	krill, live mosquito fish, isopods, amphopods, trout chow, catfish chow, tetramin
4. Mugilids (mullet)	
adult	catfish chow, "Awa mix" (see appendix), "lab-lab" (benthic agal growth)
juveniles	brine shrimp, krill, amphipods, isopods or bottom growth
larvae	rotifers, copepods, aplesia larvae, brine nauplii
5. Chaetodontids (butterflys)	krill, tetramin, amphipods and isopods, trout chow, brine shrimp
6. Kuhliaids (aholehole)	trout chow, krill, catfish chow, mosquito fish, chopped fish
7. Chanids (awa)	catfish chow, "awa mix", benthic growth
juveniles	rotifers, ground tetramin, poultry starter
8. Acanthurids (surgeons)	chopped spinach, ocean rocks, amphipods, krill, catfish chow, isopods
9. Octopus	live crabs, small fish (wounded)
juveniles	small crabs, brine shrimp
10. Cowries	ocean rocks, diatoms of tank side
11. Tilapia	catfish chow, awa mix, trout chow, krill

* feeds are rated in order of appearance based on roughly palatability, fish survival, cost and fouling rate

Several specific ingredients and one diet, awa mix (see appendix), were lightly experimented with. The awa mix was developed because there was nothing commercially available for awa and mullet. This was necessary for these fish had to be kept in good condition if they were expected to sexually mature. This feed worked well as a supplement to outdoor tanks. However, it clouded the water badly and was observed to foul the gills of fish, and therefore, needed to be bound to prevent clouding. If used as the sole food source, as in indoor tanks, the fish would develop a fatty liver and a thick abdominal adipose layer of hard, flaky fat and not develop gonads. Awa fry kept indoors would have hemorrhaging eyes and operculuns that flared outword if feed just awa mix.

Ground coconut was attempted as a feed additive. A grinding process on first coarse chopping, then freezing and grinding at 2 mm while still frozen worked best. Coconut was used in an attempt to increase the amount of fats in the fish diet. There was no observed difference in acceptability when 5 to 10% was added to a feed source. Unfortunately, coconut was not part of a diet long enough to be properly judged as a food source. This was the same situation encountered when other feeds were experimented with. Some of the other experimental feeds were sea lettuce (Ulva lactoca) and blue-green algae (Spiralina sp.).

Malnutrition was an important problem encountered with the captive fish especially the members of the surgeon family. These fish would not respond when given disease treatments or improve if given a change in diet. However, it was found that if given algal rocks in addition to a variety of diets fish generally improved.

Any feed source that was not live had to be removed after 30 minutes, since it would spoil and unnecessarily stress the fish. For this reason, fish would not be able to eat except when fed and this does not allow for optimum growth. It was important to feed fish every day at regular intervals.

However, the biggest problem I felt in feeding of fish is the fact that only a few to none of the nutritional requirements of aquatic species are known. How can one really know what to feed the fish if one does not know its requirements?

5.00 DISEASE IDENTIFICATION AND TREATMENT

There were basically two types of diseases that occured while at Oceanic Institute. The first was mentioned in the quarantine and conditioning section. This type of disease originated through mechanical injury and the other stresses of capture and handling. As mentioned previously these injuries do not appear until a couple of days after handling. The second disease type occurs after the fish have been conditioned to the captive environment.

If the tank environment was kept clean and well aerated the chance of disease was reduced. The parasitic copepod was the only problem of healthy fish that I found. Infected fish would swim irradically or sometimes sit on the bottom near slack water. Lice-like copepods could be seen on the surfaces of the fish, especially along the fins and under the jaw. It was usually treated with a formalin bath (1 ml : gallon) for one hour.

As far as other diseases were concerned I knew little. Fish that were conditioned were fed what was assumed to be beneficial. Sometimes all the fish in a tank would die overnight; or just a few in a specific tank periodically; or at times a few would behave abnormally and be okay later and some would even have no problems at all.

5.10 IDENTIFICATION

Fish were checked for disease usually when being fed. Some of the abnormalities looked for at this time were dark colored fish and loss of appetite. Flashing could indicate ectoparasites. Any mortalities found could mean something was wrong. Popeye was a common disorder, but could mean almost anything. Swimming peculiarities, swollen bellies and an overall wasting away were all symptoms that were looked for while feeding the fish. I casually noted the fish behavior before, during and after feeding. Table 3 is a list of pathogens and symptoms[6].

Fish that displayed any symptoms were captured and observed closely at the fins, skin and if possible in the gills for peculiarities. If the fish is weak it can be sacrificed and autopsied. The following procedure was recommended by Dr. Gratzek at Waikiki fish pathology work shop[7]. First prepare wet mounts using water the fish was in to prevent osmotic stress. Mounts were made of the skin, fins, gill filaments, liver, gut and kidney. After every slide was observed under a microscope one would sometimes note a pathogen of some sort. If not one can continue checking elsewhere, and hope to find something. Without practice and good training I could not often determine the cause of disease.

5.20 TREATMENTS

A list of treatments for diseases is on Table 4[8]. I have not used all of these treatments. Furacin[R], a nitrofurozone was used for bacterial problems and first aid for mechanical injuries. Formalin was used on ectoparasites, protozoans and as a general disinfectant. Fresh water was used chiefly as an anti-crustacean measure; it took at least one day to convert entirely to fresh water. Malachite green was used as a dip or flush; alone or at times together with formalin for tough protozoans like cryptocarion, for fungi or for a general disinfectant. Copper sulfate and potassium permaganate were used very little. The copper was used more as a preventive measure and potassium permaganate was used to sterilize empty tanks.

Table 3 Principal Infectious Diseases of Tropical Fish and Their Main Symptoms*

Pathogens (disease-causing organisms)	Visible Symptoms
Viruses	
Lymphocystis (fw, sw)**	large compound white knots on skin and fins, especially on pectoral axil
Bacteria	
Eubacteriales (gram-negative)	
Aeromonas (fw, sw) (ascites)	swollen body, ulcers (open wounds), white or red patchy discoloration, fin rot, red discoloration of the anus, eyes sunken
Pseudomonas (fw, sw) (dermatitis)	ulcers, fin rot
Vibrio (sw)	red patchy discoloration, fin rot, ulcers, eye discoloration, body degeneration, scale loss
Haemophilus (fw)	white spots quickly developing into round ulcers, inflamed jaws and palate, ulcers to bone, fin rot
Actinomycetales (acid fast)	
Mycobacterium (fw, sw) (fish tuberculosis)	pallor, milky or red spots on skin, ulcers, popeye, fin degeneration, loss of weight, jerky movements
Myxobacteriales (gram-negative)	
Cytophaga (fw, sw) = Chondrococcus (columnaris disease)	grey or white spots, shallow ulcers, fins frayed, gill filaments swollen or fused
Fungi	
Ichthyosporidium (fw,sw)	loss of equilibrium, ulcers
Ichthyophonus (fw, sw)	mouth partly open, loss of fins, black discoloration
Saphrolegnia (fw)	deposits on skin that look like cotton wool

Protozoa	
Flagellata	
Costia (fw) (slimy skin disease) internal flagellates (fw)	pallor on skin and gills, skin shedding, weight loss, listlessness
Dinoflagellata	
Oodinium (fw, sw) (velvet or rust disease)	numerous tiny spots on fins, body and gills
Sporozoa	
coccidians, myxosporidians (fw, sw) (internal - usually found in wild fish)	abdominal swelling, reddening of anal pore
microsporidians (usually found in wild fish)	
Glugea (fw)	round pea-sized white cysts
Plistophora (fw, sw) (neon fish disease)	swelling, paralysis, fin degeneration
haplosporidians (fw)	cylindrical, large, white cysts
Cilliata	
Ichthyophthirius (fw) (Ich or white spot disease)	white granules on skin and fins; tail rot; stiffness of pectoral fines
Cryptocarion (sw) (Ich)	as above for marine fishes (Ichthyophthirius)
Metazoa (commonly called "worms")	
monogenetic trematodes (fw,sw) (flukes)	often a bluish white membrane on skins and gills (Flukes live in gut, blood, eyes, liver)
nematodes (Cammalanus)	red worms protrude from anus
tapeworms	belly becomes swollen
leeches (fw, sw)	visible on body
Crustacea	
copepods (fw, sw) (anchor worms)	either parasites are visible or there are round, red or white, walled defects or swelling on skin, fins and gills

Isopods (fw, sw) (tongue worms)	visible in mouth and gills

*Chave, EH and Lobel, PS: Marine and Freshwater Aquarium Systems for Tropical Animals, Sea Grant Advisory Report UNIHI-59-AR-74-01, April, 1974.

** fw = freshwater organism   sw = saltwater organism

Biological controls were not considered except for maybe the use of small aholehole (<u>Kulia sandvicences</u>) to control the invertebrate population in ponds which had parasitic copepods.

There were some problems that appeared prone to certain fish groups; for example, the acanthurids developed a gasious popeye which later filled with blood. Symptoms continue until the fish died and no treatment given appeared to cure it. Members of the Naso genus seemed susceptible to a blistering of the skin in addition to popeye.

5.30 DISCUSSION

It appears the diseases were the result usually of a fish that was not really adapted to our confinement to begin with. They became weak and susceptible to disease. It is therefore crucial to find a favorable environment for the fish. Once a disease was contracted; however, it was attempted to be diagnosed and treated not often with much success.

It had been learned that prevention was the best means to control disease. For this reason new fish were quarantined and the muck in ponds cleaned out, since they provide many types of protozoans. Periodic treatments with an antiseptic were practices to keep diseases under control.

Table 4 Treatments for Fish Diseases **

Disease Categories and Medications	Dosages and Comments
Bacterial Diseases	
Gram-negative bacteria	
Aureomycin* (Chlorotetracycline)	Bath: 50mg/gal water for 6 days
Chloromycetin* (Chloramphenicol, Amphicol-V)	Food: 2 - 5 mg/100 g fish for 14 days Bath: 250mg/gal water for 6 days.
Erythromycin* (Maracin)	Food: 10mg/100 g fish for 21 days
Furanase (10% activity)	Bath: 4mg/gal water each day for 4 days, then 2mg/gal for 2 days
Mefural (Benzalkonium chloride)	Bath: 6mg/gal water for 6 days
Polycillin* (Ampicillin trihydrate)	Bath: 250mg/gal water for 6 days
Terramycin* (Oxytetracycline)	Food: 5 - 10 mg/100 g fish for 11 days
Vitamin B1	Food: large amounts for 7 days
Acid-fast and gram-positive bacteria	
Garamycin Icanamycin Isonicotinic acid hydrozide	These might work, but we know of no tests on fishes.
Fungal Diseases	
Acriflavine+ (for eggs and larvae only)	Bath: 40mg/gal water until larvae are about 2 weeks old
Amphotericin B*"	Bath: 1 part/10 million parts water for 7 days
Griseofulvin	Bath: 30mg/gal water for 1 to 2 days
Malachite green chloride+ (zinc free)	Bath: Use 1% stock solution - add 1 drop/gal water for 3 days the 1 drop/2 gal for 4 days (Salt water: 3ml/100 gal)

Potassium permanganate+	Bath:	Use 37% solution - 38 ml/ gal water for 30 minutes
Salt	Bath:	Add 5 doses, each 1 level teaspoonful/gal water at intervals of a few hours
Sulfathiozole sodium+	Bath:	1 level teaspoon/gal water for 14 - 20 days
Ectoparasites		
Formalin (Formaldehyde 37%)	Bath:	37% solution - 1 ml/gal water for 1 hour; repeat 3 times at intervals of 3 - 4 days
Malachite green chloride	(see Fungal diseases)	
Masoten (Trichlorfon)	Bath:	1.2 mg/gal water for 3 - 4 days
Mercurochrome	Crush the parasite or pull it out and apply medicine to wound directly	
Potassium permanganate	(see Fungal diseases)	
Protozoan Diseases		
Oodinium and other flagellates		
Copper sulphate	Bath:	Use stock solution 2.23 g hydrated copper sulphate and 1.5 g citric acid in 1 liter water - add 1 ml/gal water for 2 weeks
Skin parasites		
Formalin	(see Ectoparasites)	
Ich and other cilliates		
Methylene blue B	Bath:	Use 5% stock solution; add 15 drops/gal of salt water for 5 days or 15 drops/gal of fresh water for 2 weeks
Potassium permanganate	(see Fungal diseases)	
Cilliates and Sporozoa		
Sulphanilamide	Bath:	380 mg/gal water for 7 days

General

Flagyl (Metronidazol)	Bath: 12 mg/gal water for 3 - 4 days
Malachite green chloride	(see Fungal diseases)
Quinine hydrochloride or sulphate	Bath: Add 3 doses, each 38 mg/gal water at 12 hour intervals; leave for 20 days
Salt	(see Fungal diseases)

Intestinal "Worms" (metazoans)

Di-n-butyl stannous oxide	Food: 1.5 mg/.10 g fish for 3 days
Hydrogen peroxide	Bath: 35% solution - 0.3 mg/gal water for 5 hours
Masoten (Trichlorfon)	Bath: 12 mg/gal for 4 days
Methylene blue B	(see Protozoan diseases)
Quinine hydrochloride	(see Protozoan diseases)

Miscellaneous Diseases

Constipation

Glycerine	Food: a small quantity mixed with dry food until condition clears

Eye problems

Neoprontosil	Coat eye and place fish in the dark

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*Will often cause side effects, and remains active for one year

+Probably fights bacterial infections and helps the fish shed the fungi

"Currently being tested

**Chave, EH and Lobel, PS: Marine and Freshwater Aquarium Systems for Tropical Animals, Sea Grant Advisory Report UNIHI-59-AR-74-01, April, 1974

6.00 INDUCEMENT OF SPAWNING AND LARVAL REARING

As mentioned in the introduction spawning is the primary concern of Oceanic Institute. The controlled reproduction of an aquaculture species is important if it is to be successful. For if you are not able to spawn a fish or selectively breed it you have nothing. Currently fish ponds are stocked with wild stock. These fish will not spawn naturally in the ponds. In fact females will fall short of complete sexual maturation, but males will develop to full maturity.

In 1971 Oceanic Institute initiated a program for spawning of mullet in captivity and in 1975 achieved world wide recognition for its success in artificially inducing mullet to spawn. This same technique is being modified for attempts at spawning awa and reef fish. My work was all centered around the spawning of these fish.

6.10 PROCEDURE FOR MULLET

The brood stock and fish from ponds were collected at their suspected peak gonad development. For mullet it was between November and March, depending on the water temperature and food availability. Field gonadal checks were given to these fish by holding the fish, in a box, upside down in the water and inserting a small bore polyethylene tube into the genital pore. The stage and level of gonadal development was determined by the mean diameter of the eggs. Mullet eggs about 0.6 mm in diameter are considered to be at the peak, this however, was not full maturity.

When a female was selected she was put into a clean tank (200 liters) of fast flowing sea water along with three ripe males, they matured naturally and three assured maximum fertilization. The female was given an intramuscular injection of a gonadotropin (12 - 21 mg/gm body weight of salmon gonadotropin or 60 IU of human gonadotropin), pituitary hormones. This first injection stimulates further development of the egg to a size of about 8.2 mm. This usually takes 24 - 48 hours. Then a second injection was given to promote hydration and ovulation of the eggs. In 12 hours the female should spawn. Hydration of the egges was noted by transparent egg samples; whereas, it was opaque before. It was also noted by a noticable swelling of the females abdomen. Calcium was also precipitated from the oviduct. Once the genital pore begins to swell and the males begin to swarm the female; you know that spawning is soon to occur[9].

Once she releases the eggs the males immediately fertilize. The water was turned off and the drain plugged to avoid loss of eggs. After fertilization the fish were removed and the eggs allowed to stay in the well aerated tank for about 1 hour to assure time to fertilize and water harden.

The water and eggs were transported to incubating tanks at a density no greater than 400 eggs per liter. The eggs were aerated just enough to assure uniform mixing and oxygen, but not enough to damage the eggs. The salt water in the tank was kept at a temperature of about 24 degrees C for about 40 hours before hatching (colder water would take longer and vice versa). A small dose of streptomycin was added to retard bacterial growth.

After the eggs hatch the air was turned off for about 20 minutes. This was just long enough to separate the denser dead eggs and the lighter egg cases. The floating debris was then aspirated off. Larvae were bucketed or siphoned into the rearing tank. The larvae were barely over 1 mm and were distributed throughout the water column.

It was found that a stocking density should be no greater than 10 larvae per liter in the rearing tank[10].

In four days the larvae depleted their yolk sac and food must be readily available. For this reason the rearing tank was stocked with a culture of rotifers at a density of about 5 - 10 rotifers per ml and in chlorella 10^4 - 10^6 per ml. After 10 days the fragile larvae begin feeding on copepods and in 18 days on newly hatched brine shrimp. By day 40 the fish were silvered and were already feeding on the sides and bottom like adults. The salinity was lowered slowly from ocean 32 to 24 parts per thousand. They are however, too delicate to handle until after 50 days, when they have enough scales for protection.

6.20 TECHNIQUES FOR OTHER SPECIES

The spawning program for awa is the same except for the time of season. However, there was not a successful spawning to date. The fish was also much more susceptible to problems due to its large size, resistance when handled, and great amount of soft adipose tissue covering the eye.

It was found that if the fish was anesthetized or restricted mechanically with soft material, then less injuries would result. The two types of anesthetics used were quinaldine sulfate and MS - 222. A transport tank was ideal for sedating the fish. Care had to be taken not to excite the fish too much before anesthetizing. If fish were just restricted, then it was best to leave the fish in the water, but secured well in a rolled up net or squeeze box lined with padding.

Spawning of reef fish was attempted in the summer of 1977 and met with some success. The long nose butterfly fish was spawned by a technique of hormone injection like that of mullet but were manually stripped of their gametes.

7.00 ANIMAL MANAGEMENT TOWARD MAINTAINING A SUITABLE ENVIRONMENT

7.10 CULTURING PRACTISES

7.11 Handling

Handling of fish should be avoided if possible because their skin is so easily injured. If it was necessary to handle the fish they were not panicked, but were held securely with a soft material and in the water if possible. Sexually mature fish were especially susceptible to stress and had to be gently handled.

7.12 Water

Fish were found to be much healthier if kept in clean, aerated water. In addition, tanks coated with a layer of algal growth had the best growth.

7.13 Stocking Density

Mullter and awa seemed to grow best when in schools large enough to be too numerous to count, but not so that they appeared to be crowded together. Predatory species, however, seemed to grow best if the tank was loosely stocked.

7.20 EQUIPMENT

Equipment was kept repaired so that it was reliable and had no rough edges that might injure the fish. Each pond was supposed to have its own bucket and dip net. They were kept near the pond in a dry, shaded location. After each use the equipment should have been disinfected to prevent spread of disease if it was used elsewhere or after the fish were cured.

7.30 RECORDS

A daily record of the fishes behavior at feeding, abnormalities, mortalities, weather, and anything considered important was taken for each pond or tank. In addition, these records kept an inventory of fish in stock. These records were important when comparing merit of different culturing systems.

8.00 CONCLUSION

Wild mullet and awa were caught at a variety of sizes using special techniques. These fish were kept separate from the resident fish until they were healed of injuries, conditioned to the captive environment and treated for parasites.

These resident fish were used mainly as brood stock for artificial inducement of spawning by hormone injections. Mullet have been successfully spawned and reared by this method, and methods for other fish were being developed.

The fish were fed what was thought to be the best diet based on what they eat in the wild and what they would accept in captivity. There were however, several instances of what appeared to be nutritional deficiencies.

There were also other types of diseases that occurred and many of them were not diagnosed. However, I felt that the over all experience as a fish production technician was rewarding in that I gained insight into what was involved in fish keeping and what needs to be done to improve it.

9.00 RECOMMENDATIONS

My supervisor once told me that fish production is both an art and a science. Some skills can be taught but many skills are only acquired by actual experience and practise. Therefore I feel that actual experience is the only real way to understand what is involved as a fish production technician.

I found that my ability to catch fish with nets made handling fish a smooth operation. In addition knowing the different species at a glance simplified handling of the fish even more. When feeding fish I knew what each fish normally ate in the wild and could guess at what they would eat, in captivity. These and several other related skills helped considerably when working as a fish production technician.

Some things that need to be improved are to better understand the nutritional requirements of the fish and to explore a greater variety of feed sources. Identification of diseases needs to be more refined, as well as, what the effective treatments are for each disease.

APPENDIX

AWA MIX

This feed was an experimental dry feed designed specifically for mullet and awa brood stock.

It consists of 30.6% crude protein and is made of:

55%	wheat middling - 1 mm
14%	fish meal - tuna meal 1 mm
14%	cotton seed meal - 1 mm
14%	soybean meal - 1 mm
3%	bakers yeast

These ingredients were mixed in a dry form and made into a pasty dough just prior to feeding. The mix was readily eaten by these fish and there was an obvious weight gain when first introduced; however, there were many problems with this feed. Fish kept indoors would not mature and develop fatty livers, an indication of nutritional deficiency. The cotton seed component was found to pass through the fish with little digestion, and the wheat was found to form a gum that was poorly digested and sometimes blocked the intestine. Yeast was found to be active and would release large amounts of gas often severely bloating the fish. Finally the silt caused by the finely ground feeds clouded the water. This irritated the fish as well as provided an excellent substrate for bacterial growth.

Because of the above reasons, the awa mix was modified by reducing the wheat component and removing the yeast and cottonseed entirely. About 40% purina catfish chow was added to supplement missing nutrients.

This was the feed in use as of August 1977. It seemed to have much less problem, but it still needed a good binder to reduce the amount of siltation.

FOOTNOTES

1 George Uemura. Commercial awa fish pond operator. Waikane, Oahu.

2 Albert Smith. Pathology, senior investigator. Oceanic Institute.

3. Kuo, CM. 1975. Recent Progress on the Control of Ovarian Development and Induced Spawning of Grey Mullet. Aquaculture 5: 19.

4 Bill Madden. Fish Production, senior investigator. Oceanic Institute.

5 Bill Madden

6 Chave, EH and Lobel, PS. 1974. Marine and Freshwater Aquarium Systems for Tropical Animals. UNIHI-SG-AR-74-01. p. 79 - 80.

7 Gratzek, J. 1976. Fish Pathology Workshop. Waikiki Aquarium.

8 Chave, EH and Lobel, PS. p. 81 - 83.

9. Kuo, CM. p. 19 - 21.

10 Nash, CE and Kuo, CM. 1975. Hypothesis for Problems Impeding the Mass Propagation of Grey Mullet and Other Finfish. Aquaculture 5: p. 131.

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